

IN THE SPECIFICATION:

Please amend paragraph number [0006] as follows:

[0006] The combustion of black powder produces a plethora of effluents. It has been calculated that the black powder combustion generates significant amounts of carbon monoxide, sulfur dioxide, and hydrogen sulfide. Potassium sulfide has been predicted to constitute over 20 percent of the combustion products. At flame temperature, potassium sulfide is produced in the liquid state and is likely to undergo after-burning with atmospheric oxygen to produce copious amounts of sulfur dioxide. The carbon monoxide and hydrogen sulfide are also susceptible to ~~after-burning~~, after-burning, yielding carbon dioxide and sulfur dioxide, respectively.

Please amend paragraph number [0008] as follows:

[0008] The charcoal constituent of black powder imparts a degree of unpredictability to the performance of the igniter composition. Charcoal is produced by carbonization of wood. As described in U.S. Patent No. 5,320,691 to Weber, the chemical and physical properties of wood vary greatly, depending upon the particular properties of the tree species, soil composition, and environmental conditions from which the wood is taken. Due to inherent variability of wood and fluctuations in the carbonization process, the properties of charcoal tend to vary from batch to batch. These variations can affect the consistency of black powder performance.

Please amend paragraph number [0011] as follows:

[0011] Another black powder substitute composition is described in U.S. Patent & Trademark Office document H72 to Wise, et al. The solid pyrotechnic composition contains 75 weight percent potassium nitrate, 10 weight percent elemental sulfur, and 15 weight percent crystalline compound. The crystalline compound may be fluorescein, phenolphthalein, ~~1,5-naphthalenediol~~, 1,5-naphthalenediol, anthraflavic acid, terephthalic acid, and alkali metal salts thereof. As in the case of other known black powder substitute compositions, H72 relies on elemental sulfur for minimizing the ignition delay of the igniter.

Please amend paragraph number [0017] as follows:

[0017] In accordance with one aspect of the invention, a solid pyrotechnic composition constituting a black powder substitute ("BPS") is provided. The composition comprises about 40 weight percent to about 90 weight percent oxidizer particles having a mean particle size of not greater than about 30 microns. The oxidizer particles comprise (a) at least one member selected from the group consisting of alkali metal nitrate and ammonium nitrate and (b) at least one member selected from the group consisting of alkali metal perchlorate and ammonium perchlorate. The preferred alkali metal is potassium. The solid pyrotechnic composition further comprises organic crystalline particles and, optionally, salts of organic crystalline particles. The organic crystalline particles and the optional salts of organic crystalline particles preferably have a mean particle size of not greater than about 30 microns and preferably account for about 10 weight percent to about 60 weight percent of the total weight of the solid pyrotechnic composition. The organic crystalline particles preferably comprise phenolphthalein.

Please amend paragraph number [0019] as follows:

[0019] In accordance with this second aspect of the invention, a solid pyrotechnic composition comprising a boron/potassium nitrate substitute is provided for attaining the immediately above-mentioned object and other objects. The composition comprises about 40 weight percent to about 90 weight percent oxidizer particles having a mean particle size of not greater than about 30 microns. The oxidizer particles comprise at least one member selected from the group consisting of alkali metal perchlorate and ammonium perchlorate. The perchlorate particles make up from about 20 weight percent to about 90 weight percent of the total weight of the composition, and more preferably 30 weight percent to 90 weight percent of the total weight of the composition. The oxidizer particles may also comprise other materials, including at least one member selected from the group consisting of alkali metal nitrate and ammonium nitrate. The preferred alkali metal for the perchlorate and the nitrate is potassium.

The solid pyrotechnic composition further comprises organic crystalline particles and, optionally, salts of organic crystalline particles. The organic crystalline particles and the optional salts of organic crystalline particles preferably have a mean particle size of not greater than 30 microns and preferably account for about 10 weight percent to about 60 weight percent of the total weight of the solid pyrotechnic composition. The organic crystalline particles are preferably phenolphthalein.

Please amend paragraph number [0020] as follows:

[0020] In their respective preferred embodiments, the selection of the ingredients of these novel black powder and B/KNO₃ substitute compositions can significantly reduce the production of harmful effluents derived from sulfur. In this way, the invention can provide an improvement in the environmental impact and worker health risks encountered during firing and conducting post-fire clean-up operations of articles using the compositions. Additionally, the solid pyrotechnic composition according to presently preferred embodiments may possess excellent impact and thermal sensitivities, thereby reducing the incipient hazards of the igniter to detonation and premature ignition via response to stimuli such as impact, friction, heat, and/or electrostatic discharge. Further, the use of organic crystalline compounds in lieu of (or in partial lieu of) crystalline salts, as well as the use of nonhygroscopic binders, can significantly lower the moisture uptake or absorption of the inventive solid pyrotechnic composition in comparison to black powder. Furthermore, the omission of charcoal from preferred embodiments of the invention can improve upon the reproducibility and uniformity of the ballistic properties of the pyrotechnic composition, as well as minimize moisture uptake of the composition.

Please amend paragraph number [0022] as follows:

[0022] In accordance with the principles of this third aspect of the invention, the ~~above-mentioned~~ above-mentioned object and other objects are attained by a process in which an alkali metal hydroxide is combined with at least one organic crystalline compound to produce a

solution comprising a salt of the organic crystalline compound. The organic crystalline compound is preferably selected from the group consisting of phenolphthalein and a compound derived from reaction between a phenolic compound and phthalic anhydride. The solution is then combined with at least one acid selected from the group consisting of nitric acid and perchloric acid. The alkali metal hydroxide reacts with the nitric acid or perchloric acid to form alkali metal nitrate particles or alkali metal perchlorate particles, respectively. Additionally, the acid serves to convert the salt back to the organic crystalline compound, while reducing the particle size of the organic crystalline compound to not greater than about 30 microns. Additional oxidizer particles having a mean particle size of not greater than about 30 microns may be added. The additional oxidizer particles comprise a perchlorate salt and/or a nitrate salt. The pyrotechnic composition may then be dried, if necessary or desired.

Please amend paragraph number [0028] as follows:

[0028] The oxidizer particles of this embodiment also comprise at least one perchlorate salt. The perchlorate salt is preferably at least one member selected from the group consisting of potassium perchlorate and ammonium perchlorate, with potassium perchlorate being preferred. When used in the preferred particulate sizes of about 30 microns or less, the perchlorate salt can be instrumental in permitting the omission of sulfur from the pyrotechnic composition without sacrificing ballistic performance. Upon ignition of the solid pyrotechnic composition, the perchlorate salt can decrease ignition delay of the pyrotechnic composition while increasing pressure rise. It is preferred that 0.5 weight percent to 30 weight percent of the total weight of the solid pyrotechnic composition consist of the perchlorate salt. More preferably, 5 weight percent to 20 weight percent of the solid pyrotechnic composition consists of the perchlorate salt.

Please amend paragraph number [0029] as follows:

[0029] The organic crystalline particles of this embodiment, as well as optionally present salts of the organic crystalline particles, account for about 10 weight percent to about 60

weight percent, more preferably 13 weight percent to 22 weight percent, of the total weight of the solid pyrotechnic composition. If a salt is present, it is preferred that at least 50 weight percent, more preferably at least 80 weight percent, and still more preferably at least 90 weight percent of the organic crystalline compound be present in a salt-free state. It is possible, and preferred, to use the organic crystalline particles alone, so that the solid pyrotechnic composition is free of any salts of organic crystalline compounds. Although the organic crystalline particles and its optional salts may have mean particle sizes as large as 100 microns, they preferably have mean particle sizes not greater than about 30 microns, more preferably not greater than 20 microns, still more preferably not greater than 15 microns, and still more preferably not greater than 10 microns.

Please amend paragraph number [0032] as follows:

[0032] The solid pyrotechnic composition of this invention may optionally contain additional ingredients, including nonhygroscopic polymeric binders, for example. Suitable nonhygroscopic polymeric binders that may be used with this embodiment of the invention include those that uptake (*i.e.*, absorb) less than 4% moisture at 75% relative humidity at a temperature of 21.1°C (70°F) over 24 hrs. Representative binders include: poly(vinyl acetate), poly(vinyl-~~acetate-
eo-vinyl~~ acetate-co-vinyl alcohol), nylon, poly(ethylene-co-vinyl acetate), polyethylene glycol, alkyl cellulose (e.g., ethyl cellulose), nitrocellulose, certain chain-extended oxetanes (e.g., polyBAMO), glycidyl azide polymer (GAP), and related polymers. ~~Suitable~~ A suitable solvent may be used in the process for dissolving the binder and lowering viscosity during production. For example, ethyl acetate is a suitable solvent for poly(vinyl acetate). In the event that the composition is free of a polymeric binder, water may be used to facilitate mixing. By way of example and not necessarily limitation, the ~~binders~~ polymeric binder may be present in the composition in a concentration of not more than about 10 weight percent, preferably 3 weight percent to 6 weight percent.

Please amend paragraph number [0034] as follows:

[0034] Compared to conventional black powder, the use of a nonhygroscopic binder and the organic crystalline compound lowers the moisture uptake of the solid pyrotechnic composition of this invention. In preferred embodiments, the moisture uptake of the solid pyrotechnic composition is not greater than 0.3 weight percent, more preferably not greater than 0.25 weight percent, at ~~75 percent~~ 75% relative humidity at a temperature of 21.1°C (70°F) over a period of 24 hours.

Please amend paragraph number [0043] as follows:

[0043] Determination of mean particle size is performed in accordance with standard ~~ISO-13320-1:1999(E)~~ ISO-13320-1:1999(E) "Particle Size Analysis-Laser Diffraction Methods," the disclosure of which is incorporated herein by express reference. Generally, this standard describes deriving mean particle size from a matrix conversion of angular light scattering intensity measurements as a function of scattering angle and wavelength of light. Suitable algorithms are based on the Fraunhauffer forward light scattering theory, which incorporates the refractive indices of both the same and the carrier medium.

Please amend paragraph number [0047] as follows:

[0047] In a 50 ml ~~Nalgene~~ NALGENE® vial, 3.78 g (18.9 weight percent) of 6-micron phenolphthalein, 12.32 g (61.6 weight percent) of 15-micron potassium nitrate, and 3 g (15 weight percent) of ~~20-micron~~ 20-micron potassium perchlorate were dry blended for ~~1 min~~ minute in a mini-paint shaker. To these powders, 2.92 g of a 30.87% poly(vinyl acetate) in ethyl acetate (4.5 weight percent PVA dry weight) as well as 2.0 g of ethyl acetate were added. The ingredients were then mixed for one minute in the paint shaker followed by scraping the edges of the ~~Nalgene~~ NALGENE® container with a spatula and another minute of mixing in the paint shaker. A portion of the ethyl acetate was allowed to evaporate at ambient temperature in a fume hood with occasional stirring. The resulting paste was granulated sequentially through a 10, 16

and 30 mesh screen. The resulting granules were dried in a 73.9°C (165°F) oven and then sieved -40/+100 mesh. Ballistic performance was determined by igniting a 2 g sample with a hot wire in a 45 cc closed bomb. Humidity uptake data were obtained by placing approximately 3 g of sample in aluminum weighing dishes in a closed container above a saturated sodium chloride solution at 21.1°C (70°F). Ballistic performance data are found in Table 1.

Please amend paragraph number [0049] as follows:

[0049] The same formulation as in Example 1 was scaled up to a 50 g size. In a 100 ml plastic vial, 9.45 g (18.9 weight percent) of 6-micron phenolphthalein, 30.8 g (61.6 weight percent) of 15-micron potassium nitrate, and 7.5 g (15 weight percent) of 20-micron potassium perchlorate were dry blended for 1 ~~min~~ minute in a mini-paint shaker. To these powders, 7.3 g of a 30.87% poly(vinyl acetate) in ethyl acetate (4.5 weight percent PVA dry weight) as well as 5.0 g of ethyl acetate were added. The sample was mixed, granulated and tested ballistically as in Example 1 and for humidity uptake as in Example 2.

Please amend paragraph number [0052] as follows:

[0052] Formulations were also prepared in which sulfur was an ingredient in addition to the ingredients listed in Example 2. The method of preparation varied such that the 70-micron phenolphthalein and the sulfur were preblended in a 125 ml plastic vial on the paint shaker in the presence of 0.635 cm (0.25 inch) diameter plastic beads before the blended material was added to the black powder substitute mix in a 20 g ~~Nalgene~~ NALGENE® vial. Ballistic data should be compared to that for Example 2 in Table 1 since this formulation has phenolphthalein with a comparable particle size.

Please amend paragraph number [0053] as follows:

[0053] This formulation containing sulfur was prepared and tested similarly to Examples 10-12, but 6-micron phenolphthalein was used in the preparation thereof and thus ~~their~~ its ballistics can be compared to those of Examples 1 and 3-9.

Please amend paragraph number [0054] as follows:

[0054] In a 50 ml ~~Nalgene~~ NALGENE® vial, 0.9 g of 85-90% KOH were dissolved in 0.9 g of water. To this solution, 2.24 g of phenolphthalein were added and the ingredients were stirred until all of the phenolphthalein was converted to its dipotassium salt, yielding a viscous violet syrup. To this syrup, 2.33 ml of 6 M nitric acid were added and this mixture was stirred until a white paste resulted. An additional 4.84 g of KNO₃ and 1.5 g of KClO₄ were added. The slurry was dried partially and granulated similarly to the paste in Example 1. Ballistic results and formulation percentages are found in Table 1.

Please amend paragraph number [0055] as follows:

[0055] In a 50 ml ~~Nalgene~~ NALGENE® vial, 2.62 g of phenolphthalein were added to 0.5 g of a 70% water/30% ethanol solution. To this slurry, 1.34 g of a 30% aqueous KOH solution were added. The ingredients were mixed, yielding a violet-red slurry, and 11.98 g of KClO₄ were added. The slurry was dried and granulated to minus 12 mesh. The performance of the high flame temperature igniter was compared to that of a B/KNO₃ formulation in reusable hardware that emulates an automotive safety bag driver's side gas generator (Figure 1). Specifically, the igniters were fired in reusable hardware designed to mimic the inflator of a driver's side automotive safety bag. The load of non-azide gas generant ("Metal Complexes For Use As Gas ~~Generants~~"; Generants," Jerald C. Hinshaw, Daniel W. Doll, Reed J. Blau, Gary K. Lund; U.S. Patent Nos. 5,592,812 (1/14/97), 5,673,935 (10/7/97), 5,725,699 (3/10/98), and 5,735,118 (4/7/98)) utilized in both tests was 38 g. Moisture uptake data and the percentages of ingredients are summarized in Table 2.

Please amend paragraph number [0058] as follows:

[0058] Table 2 demonstrates the high moisture uptake that a crystalline salt of phenolphthalein has in comparison to phenolphthalein in its organic crystalline state. The ratio of organic crystalline compound to salt has an inverse relationship to moisture uptake, i.e., as the ratio ~~increased~~, increases, the moisture uptake ~~decreased~~, decreases.